

We claim:

1. A method for preparing chemically treated pulp fiber comprising:

- 5 a) creating a fiber slurry comprising process water and pulp fibers;
 b) transporting said fiber slurry to a web-forming apparatus of a pulp sheet
machine and forming a wet fibrous web;
 c) drying said wet fibrous web to a predetermined consistency thereby forming a
dried fibrous web; and,
10 d) treating said dried fibrous web with a chemical additive thereby forming a
chemically treated dried fibrous web containing chemically treated pulp fibers;
wherein said chemically treated pulp fibers retain from between about 10 to about 100
percent of applied amount of said chemical additive when said chemically treated pulp fibers
are redispersed in water.

15 **2.** The method of Claim 1, further comprising transporting said chemically treated dried
fibrous web to a paper machine and mixing said chemically treated dried fibrous web with
water to form a chemically treated pulp fiber slurry, wherein said chemically treated pulp
fiber slurry containing said chemically treated pulp fibers having said chemical additive
20 retained thereby.

3. The method of Claim 1, wherein said dried chemically treated fibrous web includes a
gradient of said chemical additive.

25 **4.** The method of Claim 1, further comprising dewatering said wet fibrous web thereby
forming said dewatered fibrous web.

5. The method of Claim 4, further comprising drying said dewatered fibrous web
thereby forming said dried fibrous web.

30 **6.** The method of Claim 5, wherein said chemically treated dewatered fibrous web
includes a gradient of said chemical additive.

7. The method of Claim 2, further comprising producing a finished paper or tissue product having enhanced quality due to the retention of said chemical additive by said pulp fibers.

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8. The method of Claim 1, 2, or 7, wherein said chemical additive is selected from the group comprising softening agents, dry strength agents, wet strength agents, opacifying agents, dyes, debonding agents, adsorbency agents, sizing agents, optical brighteners, chemical tracers, and mixtures thereof.

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9. The method of Claim 1, 2, or 7, wherein said softener is selected from the group consisting of quaternary ammonium compounds, quaternized protein compounds, phospholipids, silicone quaternaries, quaternized, hydrolyzed wheat protein/dimethicone phosphocopolyol copolymer, organoreactive polysiloxanes, polyhydroxy compounds, and silicone glycols.

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10. The method of Claim 1, 2, or 7, wherein said chemical additive is a softener.

11. The method of Claim 1, 2, or 7, wherein said chemical additive is an adsorbency agent.

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12. The method of Claim 1, 2, or 7, wherein said chemical additive is a wet strength agent.

13. The method of Claim 1, 2, or 7, wherein said chemical additive is a dry strength agent.

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14. The method of Claim 1, further comprising creating a chemically treated pulp fiber slurry by redispersing said chemically treated dried fibrous web in water.

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15. The method of Claim 1, wherein said chemical additive is applied to said dried fibrous web in an amount of at least about 0.1 kilograms per metric ton or greater.

16. The method of Claim 1, wherein said dried fibrous web has a consistency ranging from about 65 percent to about 100 percent.

5 **17.** The method of Claim 1, wherein said dried fibrous web has a consistency ranging from about 85 percent to about 95 percent.

18. The method of Claim 1, wherein sufficient residence time is provided after said chemical additive is applied to said dried fibrous web to allow for retention of said chemical
10 additive by said pulp fiber of said dried fibrous web.

19. The method of Claim 1, further comprising forming a paper or tissue product from said chemically treated dried fibrous web.

20. A paper or tissue product made using the method of Claim 1.

21. The paper or tissue product of Claim 20, wherein the amount of said chemical additive applied to said dried fibrous web is about 0.1 kilogram per metric ton or greater.

15 **22.** A method for applying a chemical additive to pulp fiber, said method comprising:
a) mixing pulp fibers with process water to form a fiber slurry;
b) transporting said fiber slurry to a web-forming apparatus of a pulp sheet machine and forming a wet fibrous web;
c) dewatering said wet fibrous web to a predetermined consistency thereby
20 forming a dewatered fibrous web; and,
d) applying a chemical additive to said dewatered fibrous web thereby forming a chemically treated dewatered fibrous web of chemically treated pulp fibers wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of said chemical additive when said chemically treated pulp fibers are redispersed in
25 water.

23. The method of Claim 22, further comprising transporting said chemically treated dewatered fibrous web to a paper machine and mixing said dried fibrous web with water thereby forming a chemically treated pulp fiber slurry, wherein said chemically treated pulp slurry containing chemically treated pulp fibers having said chemical additive retained thereby.

24. The method of Claim 22, wherein said chemically treated dried fibrous web includes a gradient of said chemical additive.

25. The method of Claim 22, further comprising drying said chemically treated dewatered fibrous web to a predetermined consistency thereby forming a chemically treated dried fibrous web.

26. The method of Claim 25, wherein said chemically treated dewatered fibrous web includes a gradient of said chemical additive.

27. The method of Claim 25, further comprising transporting said chemically treated dried fibrous web to a paper machine and mixing said dried fibrous web with water thereby forming a chemically treated pulp fiber slurry, wherein said chemically treated pulp slurry containing chemically treated pulp fibers having said chemical additive retained thereby.

28. The method of Claim 27, further comprising transporting said chemically treated pulp fiber slurry through said paper machine to form a finished paper or tissue product having enhanced quality due to the retention of said chemical additive by said chemically treated pulp fibers.

29. The method of Claim 27, wherein the amount of said chemical additive retained by said chemically treated pulp fibers is about 0.1 kilogram per metric ton or greater, and the amount of unretained said chemical additive in said water is between 0 and about 50 percent of the applied amount of said chemical additive retained by said chemically treated dewatered fibrous web when said chemically treated pulp fibers are redispersed in water.

30. The method of Claim 22, wherein the amount of said chemical additive applied to said dewatered fibrous web is about 1 kilograms per metric ton or greater.

31. The method of Claim 22, wherein the amount of said chemical additive applied to said dewatered fibrous web is about 3 kilograms per metric ton or greater.

32. The method of Claim 22, wherein the amount of said chemical additive applied to said dewatered fibrous web is about 5 kilograms per metric ton or greater.

33. The method of Claim 22, wherein said chemical additive is selected from the group comprising softening agents, dry strength agents, wet strength agents, opacifying agents, dyes, debonding agents, absorbency agents, sizing agents, optical brighteners, chemical tracers, and mixtures thereof.

34. A paper or tissue product made from said chemically treated pulp fiber slurry of Claim 22.

35. A method for applying a chemical additive to pulp fiber, said method comprising:

- a) creating a fiber slurry comprising process water and pulp fibers;
- b) transporting said fiber slurry to a web-forming apparatus of a pulp sheet machine and forming a wet fibrous web;
- c) dewatering said wet fibrous web to a predetermined consistency thereby forming a dewatered fibrous web;
- d) applying a first chemical additive to said dewatered fibrous web thereby forming a chemically treated dewatered fibrous web of chemically treated pulp fibers wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of said first chemical additive when said chemically treated pulp fibers are redispersed in water;
- e) applying a second chemical additive to said chemically treated dewatered fibrous web, wherein said chemically treated dewatered fibrous web contains said chemically treated pulp fibers wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of said second chemical additive when said chemically treated pulp fibers are redispersed in water; and,

f) drying said chemically treated dewatered fibrous web to a predetermined consistency thereby forming a chemically treated dried fibrous web wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of at least each of said first and second chemical additives when said chemically treated pulp fibers are redispersed in water.

36. The method of Claim 35, further comprising transporting said chemically treated dried fibrous web to a paper machine and mixing said chemically treated dried fibrous web with water to form a chemically treated pulp fiber slurry, wherein said chemically treated pulp fiber slurry contains chemically treated pulp fibers having said first and second chemical additive retained thereby.

37. The method of Claim 35, wherein said chemically treated dewatered fibrous web includes a gradient of said first chemical additive.

38. The method of Claim 35, wherein said chemically treated dried fibrous web includes a gradient of said first chemical additive.

39. The method of Claim 35, wherein said chemically treated dewatered fibrous web includes a gradient of said second chemical additive.

40. The method of Claim 35, wherein said chemically treated dried fibrous web includes a gradient of said second chemical additive.

41. The method of Claim 36, further comprising producing a finished paper or tissue product having enhanced quality due to the retention of said first and second chemical additives by said chemically treated pulp fibers.

42. The method of Claim 35, 36, or 41, wherein said first chemical additive is selected from the group comprising softening agents, dry strength agents, wet strength agents, opacifying agents, dyes, debonding agents, absorbency agents, sizing agents, optical brighteners, chemical tracers, and mixtures thereof.

43. The method of Claim 42, wherein said softening agent is selected from the group consisting of quaternary ammonium compounds, quaternized protein compounds, phospholipids, silicone quaternaries, quaternized, hydrolyzed wheat protein/dimethicone phosphocopolyol copolymer, organoreactive polysiloxanes, polyhydroxy compounds, and silicone glycols.

44. The method of Claim 35, 36, or 41, wherein said second chemical additive is selected from the group comprising softening agents, dry strength agents, wet strength agents, opacifying agents, dyes, debonding agents, absorbency agents, sizing agents, optical brighteners, chemical tracers, and mixtures thereof.

45. The method of Claim 44, wherein said softening agent is selected from the group consisting of quaternary ammonium compounds, quaternized protein compounds, phospholipids, silicone quaternaries, quaternized, hydrolyzed wheat protein/dimethicone phosphocopolyol copolymer, organoreactive polysiloxanes, polyhydroxy compounds, and silicone glycols.

46. The method of Claim 35, wherein said first and second chemical additives are applied to said dewatered fibrous web simultaneously.

47. The method of Claim 35, wherein said first chemical additive is applied to said dewatered fibrous web in an amount of about 0.1 kilograms per metric ton or greater.

48. The method of Claim 35, wherein said second chemical additive is applied to said dewatered fibrous web in an amount of about 0.1 kilogram per metric ton or greater.

49. The method of Claim 35, wherein said chemically treated dried fibrous web has a consistency ranging from about 65 percent to about 100 percent.

50. The method of Claim 35, wherein said chemically treated dried fibrous web has a consistency ranging from about 85 percent to about 95 percent.

51. The method of Claim 35, wherein sufficient residence time is provided after said first chemical additive is applied to said dewatered fibrous web to allow said first chemical additive to be retained by said chemically treated pulp fiber.

5 **52.** The method of Claim 35, wherein sufficient residence time is provided after said second chemical additive is applied to said dewatered fibrous web to allow said second chemical additive to be retained by said chemically treated pulp fiber.

53. A paper or tissue product made using the method of Claim 35.

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54. A method for applying chemical additives to pulp fiber, said method comprising:

- a) mixing pulp fibers with process water to form a fiber slurry;
- b) transporting said fiber slurry to a web-forming apparatus of a pulp sheet machine and forming a wet fibrous web;
- 15 c) dewatering said wet fibrous web to a predetermined consistency thereby forming a dewatered fibrous web;
- d) drying said dewatered fibrous web to a predetermined consistency thereby forming a dried fibrous web; and,
- 20 e) applying a first chemical additive to said dried fibrous web and applying a second chemical additive to said dried fibrous web thereby forming a chemically treated dried fibrous web containing chemically treated pulp fibers wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of at least each of said applied first and second chemical additives when said chemically treated pulp fibers are redispersed in water.

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55. The method of Claim 54, wherein said chemically treated dewatered fibrous web includes a gradient of said second chemical additive.

56. The method of Claim 54, wherein said chemically treated dried fibrous web includes
30 a gradient of said second chemical additive.

57. The method of Claim 54, further comprising transporting said chemically treated dried fibrous web to a paper machine and mixing said chemically treated dried fibrous web with water to form a chemically treated pulp fiber slurry, said chemically treated pulp fiber slurry containing chemically treated pulp fibers having at least said first and second chemical additives retained thereby.

58. The method of Claim 54, further comprising transporting said chemically treated pulp fiber slurry through said paper machine to form a finished paper or tissue product having enhanced quality due to the retention of at least said first and second chemical additives by said chemically treated pulp fibers.

59. The method of Claim 57, wherein the amount of said first chemical additive retained by said chemically treated pulp fibers of said chemically treated dried fibrous web is about 0.1 kilogram per metric ton or greater, and the amount of unretained said first chemical additive in said water is between 0 and about 90 percent of the applied amount of said first chemical additive when said chemically treated pulp fibers are redispersed in water.

60. The method of Claim 57, wherein the amount of said second chemical additive retained by said chemically treated pulp fibers is about 0.1 kilogram per metric ton or greater, and the amount of unretained said second chemical additive in said water is between 0 and about 90 percent of the applied amount of said second chemical additive when said chemically treated pulp fibers are redispersed in water.

61. The method of Claim 57, wherein the amount of said first chemical additive retained by said chemically treated pulp fibers is about 0.1 kilograms per metric ton or greater, and the amount of unretained said first chemical additive in said water is between 0 and about 90 percent of the applied amount of said first chemical additive when said chemically treated pulp fibers are redispersed in water and wherein the amount of said second chemical additive retained to said pulp fibers is about 0.1 kilogram per metric ton or greater, and the amount of unretained said second chemical additive in said water is between 0 and about 90 percent of the applied amount of said second chemical additive when said chemically treated pulp fibers are redispersed in water.

62. A paper or tissue product made using the method of Claim 54.

63. A method for adding at least a first chemical additive to pulp fiber, said method comprising:

- a) mixing pulp fibers with process water thereby forming a fiber slurry;
- b) transporting said fiber slurry to a web-forming apparatus of a pulp sheet machine;
- c) dewatering said fiber slurry thereby forming a crumb pulp; and,
- d) applying at least a first chemical additive to said crumb pulp thereby forming a chemically treated crumb pulp containing chemically treated pulp fibers;

wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of said chemical additive when said chemically treated pulp fibers are redispersed in water.

64. The method of Claim 63, further comprising transporting said chemically treated crumb pulp to a paper machine and mixing said chemically treated crumb pulp with water to form a chemically treated pulp fiber slurry, wherein said chemically treated pulp fiber slurry contains chemically treated pulp fibers having at least said first chemical additive retained thereby.

65. The method of Claim 64, further comprising transporting said chemically treated pulp fiber slurry through said paper machine to form a finished paper or tissue product having enhanced quality due to the retention of at least said first chemical additive by said chemically treated pulp fibers.

66. The method of Claim 63, further comprising applying a second chemical additive to said chemically treated crumb pulp.

67. A method for applying chemical additives to pulp fiber, said method comprising:

- a) mixing pulp fibers with process water to form a fiber slurry;
- b) transporting said fiber slurry to a web-forming apparatus of a pulp sheet machine and forming a wet fibrous web;

- 5 c) dewatering said wet fibrous web to a predetermined consistency thereby forming a dewatered fibrous web;

 d) applying a first chemical additive to said dried fibrous web to said dewatered fibrous web thereby forming a chemically treated dewatered fibrous web;

- 10 e) drying said chemically treated dewatered fibrous web to a predetermined consistency thereby forming a dried fibrous web; and,

 f) applying a second chemical additive to said dried fibrous web thereby forming a chemically treated dried fibrous web containing chemically treated pulp fibers;

wherein said chemically treated pulp fibers retain from between about 10 to about 100 percent of applied amount of at least each of said first and second chemical additives when said chemically treated pulp fibers are redispersed in water.

68. The method of Claim 67, wherein said chemically treated dewatered fibrous web includes a gradient of said first chemical additive.

69. The method of Claim 67, wherein said chemically treated dried fibrous web includes a gradient of said first chemical additive.

70. The method of Claim 67, wherein said chemically treated dried fibrous web includes a gradient of said second chemical additive.

71. The method of Claim 67, further comprising transporting said chemically treated dried fibrous web to a paper machine and mixing said chemically treated dried fibrous web with water to form a chemically treated pulp fiber slurry, said chemically treated pulp fiber slurry containing chemically treated pulp fibers having at least said first and second chemical additives retained thereby.

72. The method of Claim 67, further comprising transporting said chemically treated pulp fiber slurry through said paper machine to form a finished paper or tissue product having enhanced quality due to the retention of at least said first and second chemical additives by said chemically treated pulp fibers.

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73. The method of Claim 71, wherein the amount of said first chemical additive retained by said chemically treated pulp fibers of said chemically treated dried fibrous web is about 0.1 kilogram per metric ton or greater, and the amount of unretained said first chemical additive in said water is between 0 and about 90 percent of the applied amount of said first chemical additive when said chemically treated pulp fibers are redispersed in water.

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74. The method of Claim 71, wherein the amount of said second chemical additive retained by said chemically treated pulp fibers is about 0.1 kilogram per metric ton or greater, and the amount of unretained said second chemical additive in said water is between 0 and about 90 percent of the applied amount of said second chemical additive when said chemically treated pulp fibers are redispersed in water.

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75. The method of Claim 71, wherein the amount of said first chemical additive retained by said chemically treated pulp fibers is about 0.1 kilograms per metric ton or greater, and the amount of unretained said first chemical additive in said water is between 0 and about 90 percent of the applied amount of said first chemical additive when said chemically treated pulp fibers are redispersed in water and wherein the amount of said second chemical additive retained by said chemically treated pulp fibers is about 0.1 kilogram per metric ton or greater, and the amount of unretained said second chemical additive in said water is between 0 and about 90 percent of the applied amount of said second chemical additive when said chemically treated pulp fibers are redispersed in water.

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76. A paper or tissue product made using the method of Claim 76.

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